Asian Journal of Fisheries and Aquatic Research

10(4): 58-63, 2020; Article no.AJFAR.62164
ISSN: 2582-3760

The Effect of Sudden Rise in Salinity on Survival Rates and Salinity Tolerance Ability of *Ctenopharyngodon idella*

Mohammed Shaker Alkhshali[1] and Hasan Ali Alhilali[2*]

[1]Department of Animal Production, Agricultural Engineering Sciences College University of Baghdad, Baghdad, Iraq.
[2]Directorate of Animal Resource, Ministry of Agriculture, Baghdad, Iraq.

Authors' contributions

This work was carried out in collaboration between both authors. Author MSA designed the study, performed the statistical analysis, wrote the protocol. Author HAA wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2020/v10i430190
Editor(s):
(1) Dr. Pınar Oguzhan Yildiz, Ataturk University, Turkey.
Reviewers:
(1) K. S. Vijay Amirtharaj, Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU), India.
(2) Abdelhamid Mohamed Abdelhamid, Mansoura University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/62164

Original Research Article

Received 06 August 2020
Accepted 10 October 2020
Published 21 January 2021

ABSTRACT

This study aimed to identify the extent of the effect of sudden rise in salinity on survival rates of *Ctenopharyngodon idella* and determine the lethal concentration (LC_{50}) that kills half of the number of fish. The fish were suddenly exposed to lethal concentrations (LC_{50} values) of: 4, 8, 12, and 16 g / l at a weight of 31.4 ± 2.2 g, as well as hypertonic water at the rate of (0.1 g of LC_{50}), which was considered as a controlling sample. The (LC_{50}) were prepared by adding a known weight of dried sea salt in a liter of chlorine-free hypertonic water until the required lethal concentrations (LC_{50}) were reached. The results of the survival rates experiment showed that the survival rate of *Ctenopharyngodon idella* reached 90%, 20% and 0% at the lethal concentration (LC_{50}) of 8, 12 and 16 g /l respectively, while the survival rate was 100% in both hypertonic water and the lethal concentration (LC50) of 4 g / l.

The results of the experiment to determine the lethal concentration (LC_{50}) that kills half of the number of fish also showed that the LC_{50} in *Ctenopharyngodon idella* reached 9.68 g / l during 96 hours of sudden exposure to LC_{50} at the rate of 0.1, 4, 8, 12 and 16 g / l. During the experiment,

**Corresponding author: Email: hassanalhilaly89@gmail.com;*

the fish were fed on food ration containing 32% protein, at the rafe of 3% of the weight of fishs' body.

Keywords: Rise salinity; survival rates; salinity tolerance; Ctenopharyngodon idella.

1. INTRODUCTION

The sudden transfer of stenohaline fish to saline water often leads to major physiological changes that need to be successfully overcome so that the fish can survive and adapt to the new environment. Moreover, the differences in the ranges of salinity that fish can tolerate are mainly due to the difference in their ability to osmotic regulation according to the different salinity levels, and to its ability to maintain the concentration of internal ions and the ability to control ion concentrations in the blood and muscle plasma [1].

The increasing salinity in fresh water bodies in the world is a serious environmental problem because of the negative effect of high salinity on the survival and living of the aquatic organisms in general and stenohaline fish in particular [2], as for Iraq, the problem of high salinity has threatened the life and spread of fish and other aquatic organisms especially in central and southern Iraq, and the reasons for that are numerous summrized in, reducing the Iraqi water comes from Turkey, increasing the flow of the drainage water from Iran and closing the courses of some rivers that entering Iraqi lands such as Alwand river as well as, global environmental problems, which are high temperatures, increasing rates of evaporation and high levels of global warming [3]. Salinity is a main abiotic factor in aquaculture and its optimum degree are specific and may affect growth, and survival success [4]

The most using and common laboratory process of measuring salinity tolerance ability in fish (Lethal Concentration LC $_{50}$) was used, which is conducted within an arbitrary period ranging between 48 - 96 hours, it is an experimental measure that establishes a causal relationship between salinity and mortality, but it does not take into account other changes that occur in the surrounding environment, which may participate in increasing salinity and causing fish mortality [5].

This study aimed to recognize the effect of the sudden rise in salinity on survival rates and high salinity tolerance ability *of Ctenopharyngodon idella*.

2. MATERIALS AND WORK METHODS

The following lethal concentrations (LC_{50}) were used: hypertonic water (0.1), 4, 8, 12 and 16 g / l, and to identify the effect of sudden transfer of fish to (LC_{50}) above on survival rates and determine the LC_{50} that kills half of the number of *Ctenopharyngodon idella* which at a weight of 31.4 ± 2.2 g. Twenty glass aquariums filled with 40 liters of water were used within the indicated concentrations, and by two repeats for each concentration. The required LC_{50} were prepared by dissolving a certain weight of sea salt (brought from Al-Mamaleh area in Al-Faw city in Basra Governorate) in a liter of hypertonic water, the salinity of the prepared salt concentrations was confirmed by measuring it with the salinometer type SA98.

After acclimating the fish to laboratory conditions for a week, the fish were transferred to the pre-prepared LC_{50}, at ten fish per repeater, the fish placed in the hypertonic water were considered as controlling sample.

The fish were fed after 24 hours of transporting them to different LC_{50} on a food ration with a protein content of 32% and 3% of body weight throughout the duration of the experiment, which lasted 96 hours, taking into consideration the preservation of water quality by providing industrial ventilation to the aquariums and changing 1/3 of water daily.

The survival rates of fish were determined from the following equation:

$$\frac{\text{The number of live fish at the end of the experiment}}{\text{The number of dead fish at the end of the experiment}} = \% \text{ Survival rate } \mathbf{100*}$$

Whereas, the salt concentration or lethal salt concentration (LC_{50}) was determined by following the equation of straight-line [6].

2.1 Statistical Analysis

The Statistical Analysis System was used in Data Analysis [7] according to the Complete Randomized Design (CRD). The significant differences between the averages of the treatments were compared using multiple range Duncan test [8] at a probability level of (0.05).

3. RESULTS AND DISCUSSION

3.1 Environmental Factors

Table 1 shows the environmental factors during the trial period, which include water temperature (°C), dissolved oxygen (mg/l) and pH in different salt concentrations.

It is clear from the table above that the water temperature, dissolved oxygen levels and pH values in the different salt concentrations (hypertonic water, 4, 8, and 12 g/l) during the experiment were not within the perfect ranges for the growth of *Ctenopharyngodon idella*, but they fall within the acceptable and safe levels of living for this fish [9].

3.2 Survival Rates and LC_{50}

Table 2 shows that the survival rate of *Ctenopharyngodon idell*a reached 100% in both hypertonic water and salt concentration 4 g/l while it was 90%, 20% and 0% at salt concentrations 8, 12 and 16 g/l, respectively, and the salt concentration of 16 g/l was excluded because of the loss of all the fish in it.

It is clear in Fig. 1, the lethal salt concentration LC_{50} reached 9.68 g / l during 96 hours of fish exposure to a sudden increase of salt concentrations at the rate of (4, 8, 12 and 16 g / l).

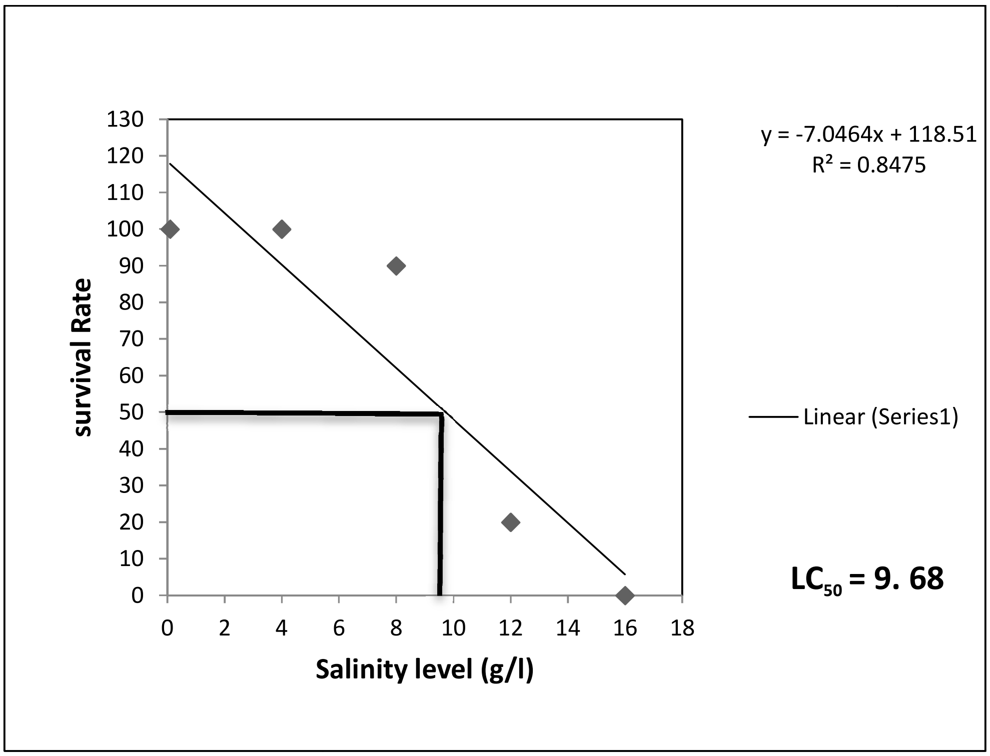

Fig. 1. The lethal salt concentration of 50% of grass carp fish during the 96 hours of sudden increase in salt concentrations (4, 8, 12 and 16 g / L)

Table 1. Environmental factors in different salt concentrations during the experiment

Salt concentration g/l	Temperature (° C)	Dissolved oxygen (mg / l)	pH
Tap water (0.01)	20-18	7.3-6.6	7.1-6.8
4	20-18	6.6-6.4	7.4-7.1
8	20-18	6.3-6.2	7.7-7.6
12	20-18	5.9-5.8	7.8-7.6

Table 2. Survival rate of *Ctenopharyngodon idella* during 96 hours of sudden increase in salinity

Salt concentration g/l	Number of fish	Survival rate (%)
hypertonic water (0.1)	10	100
4	10	100
8	10	90
12	10	20
16	10	0

4. DISCUSSION

The high mortality rates and the low survival rates of fish at the sudden rise in salinity levels compared to their natural levels can be attributed to the failure of the ionic and osmotic regulation mechanism [10], or the reason may be due to the higher osmotic concentration of blood plasma as a result of increased ion concentrations and the inability of the fish to confront this rise and get the ionic concentrations back to their normal levels [11]. So, most fish attempt to withstand the osmotic shock when suddenly exposed to water of different osmotic pressure through the mechanisms of osmotic and ionic regulation that produce a state of balance between body fluids and the external environment [12].

Kilambi and Zadinak [13] observed that *Ctenopharyngodon idella* juveniles could perish by exposing them to a salinity of 11 g / l.

Jasim [14] showed that exposure to the salinity of 10 g / l led to the death of young goldfish *(Carassius auratus*) 24 hours after exposure to salinity, while [15] did not record any deaths reported in the juveniles of golden fish exposed to saline concentrations of 2 4, 6, 8 and 10 g / l for 21 days.

The results of the current study may agree or differ with the results of previous studies, and this may be due to the difference in the sizes of fish used in the experiments and their ages, or the type of salt used in preparing the salt concentrations, or it may be due to the differences in the design of the experiments according to the different purpose of them.

Maceina and Shireman [16] stated that the lethal salt concentration (LC*50*) of *Ctenopharyngodon idella* after 24, 48 and 96 hours of its adaptation to the salinity of 8 g / l reached 15.7, 15.1 and 15.1 g / l, respectively, While no mortalities were recorded in fish when salinity reached 14 g / L during 96 hours.

Al-Khshali and Al-Hilalli [17] showed The results of the experiment of survival ratio that had lasted 96 hours showed that the value of LC_{50} amounted to 17 g/l, and as regards to the effect of salinity in some of the physiological parameters of fish, it was observed that the gradual rise of salinity to 5,10 and 15 g/l led to disturbances in all fish. Al-Daham et al. [18] stated that *Ctenopharyngodon idella* juveniles bear the sudden changes in salinity up to 15 g / l. And [13] clarified that *Ctenopharyngodon idella* tolerated the salinity to 16 g / L for a very short period and then perished.

Enayati [19] indicated that *Ctenopharyngodon idella* can cross the fresh waters (drinking waters) of the Caspian Sea, whose salinity is up to 16 g / l. And in subsequent studies on other types of the Cyprinidae family which *Ctenopharyngodon idella* belongs to, [20] showed that goldfish can survive for long periods in saline concentrations less than 10 g / l and for a short period in high salinity.

Dubey [21] made two experiments, the purpose of the first one was to determine the median lethal salinity ($MLS\text{-}_{50}96h$) and that of the second one was to assess survival and growth of the fish at different sub-lethal salinities under field conditions. 5, 10, 15, 18 and 20 g l−1 salinities were used initially to determine the range of salinity tolerance. After 100% mortality had been obtained at 20 g l−1 in the first phase, a definitive salinity tolerance test was carried out in the next phase to find out the median lethal salinity by direct exposure of the test species to 10–18 g l−1 salinity for 96 h. The estimated $MLS\text{-}_{50}$ 96h for *C. punctata* (11.50 cm length; 12.05 g weight) was 13 g l−1. In the second experiment, survival and growth performances of the fish were recorded at two sub-lethal salinities viz., 5 and 10 g l−1, along with those in fresh water as a control. Survival of the fish significantly depended on salinity, decreasing to 88.33% at exposure to 10 g l−1 salinity. Results of the present study indicate that *C. punctata* exhibits good tolerance to low salinities only (<10 g l−1) demonstrating that it is a stenohaline freshwater fish.

Giffard-Mena et al. [22] showed by explore its osmoregulatory capabilities, totoaba specimens were exposed to different salinity conditions (from 5 to 40 psu) under laboratory trials. Several developmental stages were tested (eggs, larvae, and juveniles) survival, However, larval stages were very dependent on external media salinity concentration. The responses to salinity acclimation and shifts in survival recorded were closely related to its migratory strategy, which can have important ecological consequences.

Sharma et al. [23] Record that Salinity tolerance in *Labeo rohita* (Hamilton 1822) fingerling was conducted for 96 h using a static, non-renewal system and LC50 determined for 48 and 96 h exposure were 9.60 and 7.72 ‰ with standard deviation 9.27-9.93 and 7.41-8.03 ‰, respectively. For sublethal study, 0, 2.5, 3.5 and 4.5 ‰ were selected to assess the chronic effect of salinity on this species. At the end of 90 days of exposure, highest mortality (43.75%) was recorded in fishes exposed to 4.5‰ salinity and least (12.5%) at 2.5 ‰ at the end of 90 days of experiment. On termination of the experiment. [24] were fed the Gold fish (*Carassius auratus*) for a period of sixty days on four diets (represented four treatments) with different ratios of sodium chloride salt, a 1, 3, 5 and 7% and the first treatment (1% salt) represented control, and then the fish suddenly exposed to five concentrations of salt is 0.1 (tap water), 5, 10, 15 and 20 g/litre to study the survival rates and calculate the lethal concentration of salt that kills the half number of fish (LC 50). The results showed a positive impact of salt feeding to raise the survival rate of goldfish after exposed to salt concentrations of 0.1, 5, 10, 15 and 20 g/litre, especially in treatments II (3% salt) and third (5% salt) compared with the control treatment (1% salt) and fourth treatment (7% salt), and the lethal concentration of half number of gold fish (LC 50) during a period of 96 hours reached 10.80, 14.20,13.15 and 11.75 g/l in the dietary salt treatments1, 3, 5 and 7% NaCl, respectively.

5. CONCLUSION

The researcher attributed the decrease in Survival Rate and LC_{50} to increased salinity and so their exposure to stress.

ACKNOWLEDGEMENT

This research was partially supported by University of Baghdad and who provided insight and expertise that greatly assisted the research. By his Labs and Staff

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/62164